1.2.25. CALCULATION AND EXPERIMENTAL VERIFICATION OF MODEL OF EDT

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Development of modern facilities of the computing engineering allows substantial appearance to automatize and facilitate the process of calculation and planning of the electromagnetic systems. For a theoretical calculation and analysis of signals of outputs of eddy-current transformers (EDT) both classic analytical methods and numeral methods based on the decision of differential or integral equalizations of the electromagnetic field well developed and tested in practice are known. Application of the transferred methods at planning of EDT allows successfully to find distributing of the electromagnetic field in an object with difficult geometry and nonlinear properties with high enough exactness, but at the heavy tolls of machine time. In this work the method of calculation is offered transformer communicating EDT with magnetic and unmagnetic standard, in basis of which analytical expressions are fixed for determination of active resistances, own inductance and mutial inductance puttees of EDT and object control. On a fig. 1 the model of EDT of communicating type is shown with the cylindrical object of control, where a magnetizing puttee with the amount of coils of W_{mag} is presented the proper coils, each of which is connected to the source EDS e_i. A measuring puttee with the amount of coils of W_m is presented the proper separate wires, which are connected to the voltmeters marked on a picture as their internal resistance of voltmeter of R_{v}. A cylindrical object is presented the set of W_{o} infinitely close located concentric coils with a section equal to the equivalent depth of penetration δ fields in material of object.

For this electric chart of VTP it is possible to make the system linear algebraic equalizations of kind:

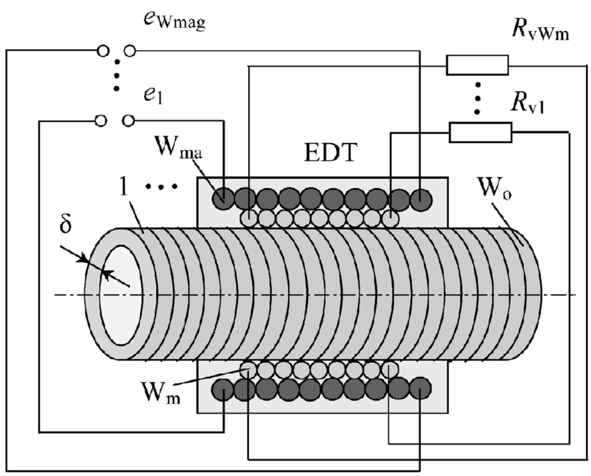

Fig. 1. The electric chart of EDT

$$\begin{cases} (R_{11} + j\omega L_{11})I_1 + j\omega M_{12}I_2 + \ldots + j\omega M_{1n}I_n = e_1 \\ \ldots \\ j\omega M_{i1}I_1 + (R_{ij} + j\omega L_{ij})I_j + \ldots + j\omega M_{in}I_n = e_i \\ j\omega M_{i1}I_1 + \ldots + j\omega M_{ij}I_j(R_{ij} + j\omega L_{ij})I_n = 0 \\ \ldots \\ j\omega M_{n1}I_1 + \ldots + j\omega M_{nj}I_j(R_{nn} + j\omega L_{nn})I_n = 0 \end{cases}, \tag{1}$$

where R_{ij} – active resistances of contours; L_{ij} – proper inductance of contours; M_{ij} – mutual inductance; e_i – EDS in any contour of magnetizing puttee, thus $e_1 = e_i = \mathrm{const}$; I_j – are currents in the proper contours.

Active resistances of the proper elements of EDT are from correlation:

$$R_{ij} = \frac{l_{ij}}{\sigma_{ij} S_{ij}}. \tag{2}$$

Proper inductances on a formula:

$$L_{ij} = \mu_0 a_{ij}\left(\ln\frac{16a_{ij}}{d_{ij}} - 2 + \frac{\mu_0\mu_{rij}}{\mu_0}\frac{\xi}{4}\right). \tag{3}$$

For finding of mutual inductance of contours used correlations, got authors in work [1] for co-operation of rings of currents from magnetic material:

$$M_{ij} = 2\pi\left(\frac{a_{\text{external}}\mu_0\mu_r}{2\pi}\sqrt{\frac{a}{a_{з\text{external}}}}f(\lambda_{з\text{external}}) - \frac{a_{\text{internal}}\mu_0\mu_r}{2\pi}\sqrt{\frac{a}{a_{\text{internal}}}}f(\lambda_{\text{internal}})\right); \tag{4}$$

$$f(\lambda_{\text{external}}) = \left(\frac{2}{\lambda_{\text{external}}} - \lambda_{з\text{external}}\right)K(\lambda_{\text{external}}) - \frac{2}{\lambda}E(\lambda_{\text{external}}); \tag{5}$$

$$f(\lambda_{\text{internal}}) = \left(\frac{2}{\lambda_{\text{internal}}} - \lambda_{\text{internal}}\right)K(\lambda_{\text{internal}}) - \frac{2}{\lambda_{\text{internal}}}E(\lambda_{\text{internal}}); \tag{6}$$

$$\lambda_{\text{external}} = \sqrt{\frac{4aa_{\text{external}}}{z_0^{\,2} + (a + a_{\text{external}})^2}}; \tag{7}$$

$$\lambda_{\text{nternal}} = \sqrt{\frac{4aa_{\text{nternal}}}{z_0^{\,2} + (a + a_{\text{nternal}})^2}}, \tag{8}$$

where a – any coil of the system; a_{external}, a_{internal} – radiuses of examined coil of the system; K, E – elliptic integrals. A receipt is detailed method of receipt mutual inductances described in work [2].

Table 1

Parameters	Calculations	Measurements	Errors
	E_c, mV	E_m, mV	γ_E, %
σ = 14.6 MS/m	56.5	57.8	2.24
σ = 49.7 MS/m, μ_r = 1.07	23.4	22.8	2.56
σ = 4.7 MS/m, μ_r = 42.5	658	735	10.47
σ = 1.48 MS/m, μ_r = 31.5	413	459	10.21

For confirmation of adequacy of the offered model were conducted calculations and experimental researches on EDT with cylindrical objects identical geometry, but with different electromagnetic properties, which are presented in a table 1.

Information of experiments showed that at scanning of object the electromagnetic field of different frequency for unmagnetic material the results of calculations and experiments go away on a size 2 – 3%. Thus for ferromagnetics, results show error in 10%, that is related to some disparity of the real and accepted in a model electromagnetic properties of control object.

References:

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2. **Горкунов Б.М., Тюпа І.В., Авраменко О.А., Скопенко В.В.** Модель параметричного вихрострумового перетворювача. Методи та прилади контролю якості // Науково-технічний журнал, ІФНТУНГ. Івано-Франківськ. – 2008. – № 21. – С. 9 – 13.